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A REMARKABLE MARL LAKE¹

EARLY in June 1900 the writer visited Littlefield Lake, Isabella county, Michigan, which, from its peculiar form, and the deposits about it, seemed worthy of special description.

The country about the lake is of a well-marked morainal structure, the till, however, being sandy in places, and noticeably gravelly and bowldery throughout, and formerly heavily covered with pine. The lake occupies a deep depression in a trough-like valley, surrounded by moderately high morainal hills, and from its apparent connection with a series of swampy valleys, suggests a glacial drainage valley, but as it was not followed for any distance its origin was not determined.

The lake itself is about one and one half miles long by three fourths of a mile broad in the widest part, which is near the middle of the long axis, and the shape is that of an irregular blunt-ended crescent. It was said to be over eighty feet deep in the deepest part, but no soundings were made by the writer. Its greatest length is from northwest to southeast, with the outlet at the southern end. There are no considerable streams entering it, but at least three small brooks, fed by springs from the surrounding hills, were noted flowing in, and the outlet is of such size that a boat may be easily floated on it at high water, although its level is maintained during the summer by a dam about two miles below the lake. The main inlet was not seen by the writer.

The shore lines are relatively regular, especially on the east and north sides, the convex side of the crescent, with banks twenty or more feet high close to the water on the east, while on the west side are two rather deeply indented bays. At either end are three small ponds, parasite or daughter-lakes, and surrounding the entire shore, except on the eastern side and the

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northeastern or inlet end, is a cedar swamp which is underlaid by marl. The outlet is through the most southerly of the daughter-lakes, and the entire shore of the lake is formed by beautifully white marl, the exposures varying in width from a few feet to three or four rods in width, so that as one overlooks the lake from one of the surrounding hills it seems to lay in a basin of white marble.

There are three small islands in the lake, two relatively near together at the northern end, and one quite near the shore at the south end. These islands are also of marl, covered partly with a thin layer of vegetable matter and a scanty growth of grass, bushes, and cedar. There is a visible connection, under water, between at least one of the islands and the nearest shore, and it is probable that all of them are thus connected by submerged banks. The marl on the islands is from twenty-five to thirty feet deep, with sand below.

Explorations in the swampy border of the lake show that the shore was formerly more irregular than now, and that the marl extends back from the water in some places for at least one fourth of a mile, gradually becoming more and more shallow until the solid gravel or clay is reached. The marl is frequently thirty feet deep along the shore, and at no place was it found to be less than fifteen feet deep at the present shore line, the shallowest places being along the shore where the high bank comes down near the water. The deepest vegetable deposit, or peat, found in one hundred and fifty borings in all parts of the deposit was three feet. The main deposits of marl are about the southeast end and along the western side of the lake, with a body of considerable size underlying a swampy area at the north end. Of the six daughter-lakes four are very small, an acre or two in extent, and entirely surrounded by deep marl, the connection between three of them and the mother-lake being shallow and narrow, a few inches deep, and a few feet wide, and only existing at high water, while two of the other three are of much larger size, with marl points extending out from either side of the strait, which is still relatively wide and deep.

Of the two bays on the west side of the lake, one is much narrower than the other, and at the mouths of both, marl points are extending towards each other to a noticeable degree.

At all points along the shore the slope of the marl is very abrupt from the shallow water to the bottom, always more than 45° , and frequently nearly 90° , this steepness being noticable in the small as well as in the parent lakes, while on the east side of the island at the south end of the lake, the wall of marl seemed positively to overhang, although this appearance was probably due to refraction.

The texture of the deepest part of this marl deposit is apparently that of soft putty; a sounding rod passed through it with comparative ease, and samples brought up have a yellowish or creamy color, which disappears as they dry, leaving the color almost pure white. At the surface the marl is coarser, slightly yellowish, and more compact. Where it lies above the water line it is distinctly made up of granular and irregular angular fragments, resembling coarse sand, but the fragments are very brittle, soft, and friable, and may be converted into powder by rubbing between the thumb and fingers.

On the parts of the shores where apparently the wave action is chiefly exerted, there are small rounded calcareous pebbles, mixed with molluscan shells, drift material, and considerable quantities of stems, branches, and more or less broken fragments of the alga *Chara*, all parts of which are heavily incrustated with calcareous matter. This *Chara* material was often piled up in windrows of considerable extent at the high-water mark.

The marl banks of the lake, from a little below the water's edge down as far as could be seen, were generally thickly covered with growing *Chara*. At the time of the writer's visit, and wherever a plant of it was examined, it had a heavy coating of limy matter, which was so closely adherent to the plant as to seem a part of it, and because of this covering the plants were inconspicuous and would easily escape notice.

Little if any other vegetation of any character was growing in the lakes at this season; indeed, from the steep slope of the

banks of marl, it would be hardly possible for any considerable amount of vegetation of higher types than algæ to flourish here, because of the lack of light at the depth at which it would have to grow to establish itself.

As *Chara* of several species is known to occur within our limits at depths as great as thirty feet, and probably grows at even greater depths where the water is clear and the bottom soil is of the right character, *i. e.*, of clay, finely divided alluvial matter, marl, etc., it is apparent that there must be an immense growth of this type of plants in such a lake as the one under discussion. That there is an abundance of *Chara* in Littlefield Lake is shown by the amount of drift material, composed of the plant, which has accumulated in heaps at the high-water wave marks along the shore at various places.

From even a casual inspection of this drift accumulation, it is evident that it is the source of much of the granular and sand-like marl on the beaches and in the coarse upper layers of the deposit. This wind-and-wave accumulated material was dry and bleached, and was very brittle—so fragile, indeed, that a mere touch was generally sufficient to break it into fragments, and it passed by insensible gradation from the perfect, unbroken, dried plant form at the high-water mark, in which every detail, even the fruit, is preserved, to inpalpable powder at and below the water's edge.

In other words, we have in *Chara*, a plant of relatively simple organization, able to grow in abundance under most conditions of light and soil which are unfavorable to more highly developed types, a chief agent in gathering and rendering insoluble calcium and other mineral salts brought into the lake from the clays of the moraine around it by the stream, spring, and seepage waters. After precipitation is accomplished and the plant is dislodged or dies it drifts ashore, where, after the decomposition and drying out of the small amount of vegetable matter, the various erosive agents at work along shore break up the incrusting chalky matter, and the finer fragments are carried into deeper water, the coarser are left along the lines of wave action.

The pebbles mentioned above as occurring on parts of the shore are also the result of the development and growth of an alga, *Zonotrichia* or a nearly related genus, a much lower type than *Chara*, having a filamentous form. The vegetable origin of these pebbles would not be suspected until one recently taken from the water is broken open, when it is found to show a radiating structure of bluish-green lines, the color indicating the presence of the plants, as it is characteristic of the group to which *Zonotrichia* belongs.

The relation of the deposits about Littlefield Lake to the direction of the prevailing strong winds of the region is probably significant.

The area of deposition is at the southeast end and along the whole western side of the lake. The winds which would be most effective in the valley of the lake would be those from the north and northwest, which would drive the surface waters down the lake toward the southern end, and, striking the shore on the eastern side, these currents would be turned across the lake to the west, depositing sediment at the turning area and in slack water beyond. The daughter-lakes are not easily accounted for except in a general sense, that they were formerly deep bays, which, by the building out of points of marl on either side of their mouths, were finally enclosed. The tendency, already noted, for existing bays to have points of marl of spitlike form extend from either side of the mouth would seem to indicate this as a probable method of formation. On the island at the south end of the lake there was manifestly a strong current, which was running southeasterly and depositing fine marl on the east side of the island, the wind, at the time the observation was made, blowing gently from a few points north of west.

As has been already noted, the islands consist of marl from twenty-five to thirty feet deep, the bottom on which they are built up being, to judge from soundings made with an iron rod, of rather fine sand. These foundations of sand have deeper water all around them, if soundings said to have been made by local fishermen can be relied upon; so it is possible they

represent shallows in the original lake bottom, upon which, after Chara had established itself, the marl accumulated, both by direct growth of the plants and by sedimentation. It may be worthy of mention that the Chara growing on the steep banks may, in part, account for their steepness by acting as holding agents, binding the particles of sediment in place by stems and the rootlike organs which the plant sends into the mud. It is probable that but a small part of the Chara that grow in the lake ever reaches the shore wave-line, and much must break up by the purely chemical processes resulting from organic decay in relatively deep water.

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